A Novel Design of Activated Carbon Saturation Monitoring System

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Abstract

The project aims to develop a low-cost and easy to produce activated carbon saturation level monitoring system. The efficiency of activated carbon in absorbing volatile organic compounds is influenced by its saturation level, so monitoring the saturation level of activated carbon is crucial to ensure its effectiveness. The proposed system utilizes the STM32F4 module to detect VOC concentration and provides real-time feedback to users through the Thingsboard cloud platform. This project not only achieves real-time monitoring of VOC concentration, but also provides technical support for environmental governance and VOC pollution.

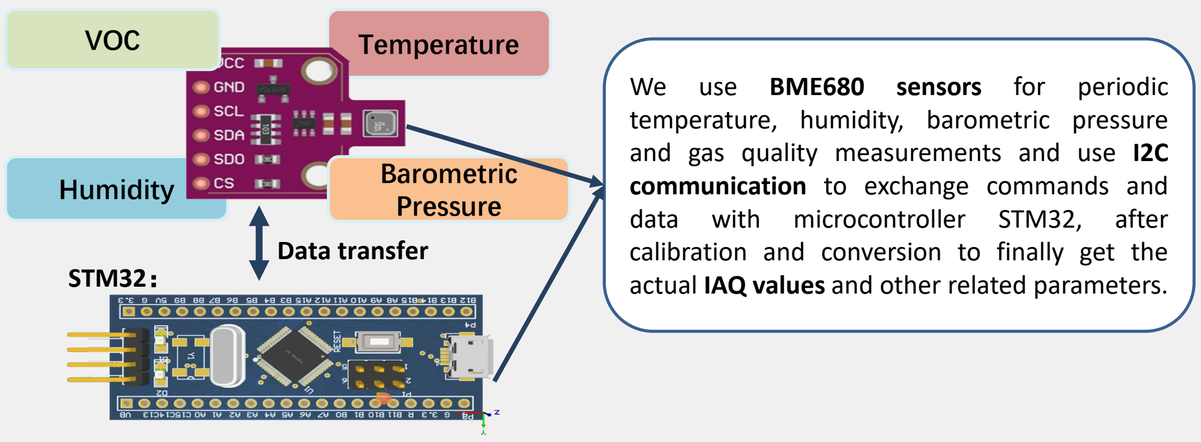
1 Introduction

In recent years, activated carbon has played an increasingly important role in absorbing volatile organic compounds. However, the saturation level of activated carbon affects the efficiency of absorbing organic compounds. Therefore, monitoring the saturation level of activated carbon is crucial to ensure its efficiency.

We chose the STM32F4 module as the hardware platform and selected BME680 sensors to monitor values. At the same time, we chose LCD screen to display real-time data. Finally, we use the ThingsBoard[1] cloud platform as the IoT software platform. After the basic functions are implemented, we evaluated the overall performance of the system.

2 Methodology

Bosch Sensortec BME680



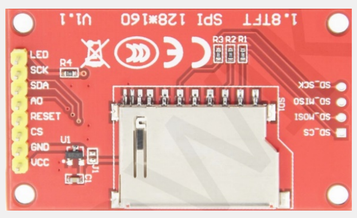
We use **BME680 sensors** for periodic temperature, humidity, barometric pressure and gas quality measurements and use **I2C communication** to exchange commands and data with microcontroller STM32, after calibration and conversion to finally get the actual **IAQ values** and other related parameters.

IAQ (Indoor Air Quality) Comparison Table

IAQ Index	Air Quality
0 – 50	good[10]
51 – 100	average
101 – 150	little bad
151 – 200	bad
201 – 300	worse[2]
301 – 500	very bad

LCD display screen

To achieve a better display effect in this project, we have chosen a 1.8-inch LCD as the display device. It can provide a resolution of 128*160 and support 65,000 colors. In order to fully utilize the MCU's IO ports, we are using the SPI protocol to transmit commands and data.



Thingsboard

Detecting signal quality to ensure **normal working conditions**

```
int match_csq(char *str, int minval, int maxval)
int module_is_ready(void)
```

Establishing a **TCP connection** with the MQTT server[2]

```
int module_connet_parm_init(void)
```

Write the **device access** token obtained from the ThingsBoard into the **MQTT related parameters**

```
If(fat_send_wait_cmdres_blocking("AT+MCONFIG
=XJTLU,XJTLU,XJTLU123456\r\n", 1000))
```

Sensors upload data in real-time to the ThingsBoard

Customize components on the platform to enable users to visualize data in real-time

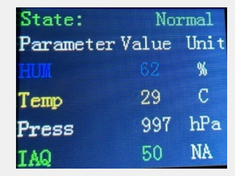
3 Result

OLED/LCD:

LCD initialization successful, background color transition from white to black, and the device name displayed in the center of the screen. After approximately 5 seconds, the interface will automatically switch to the main screen.

Upon entering the main screen, the system will automatically collect sensor data and convert them. If the data is abnormal, the system will display an error, which could be caused by sensor malfunctions or activated carbon saturation.

If the data falls within the normal range, the system will select different colors based on the data values and display it in tabular form for easy user browsing.

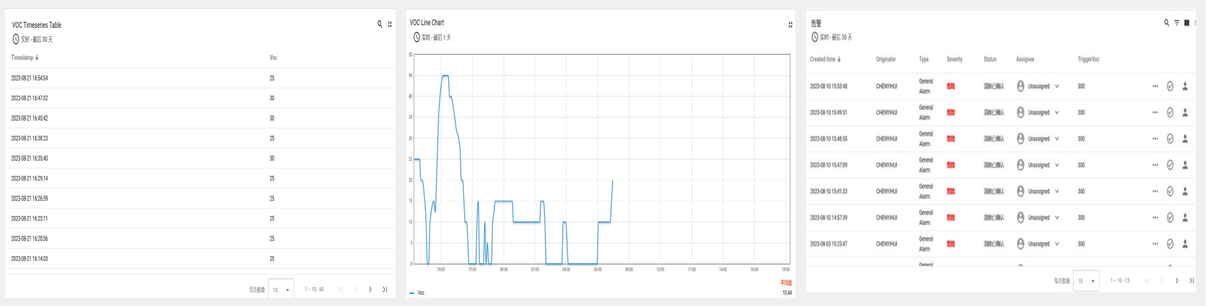


Status of sensor:

We monitor the saturation of activated carbon, and the dashboard contains a digital gauge that represents the saturation level of the sensor's activated carbon.

Visualization of telemetry data & Alarm:

We have created three separate panels, and the VOC time series table uploads three values every ten minutes. The VOC line chart displays real-time data, which is the total average value. When the VOC concentration in the air exceeds our defined limit value, an alarm will be created that includes the initiator, alarm type, severity, and status.



4 Appliaction

VOC (volatile organic compounds) detection instruments have shown extraordinary potential in various fields such as environmental monitoring and emergency response, industrial monitoring and control, and health research. VOC detection instruments play a crucial role in residential and educational environments.

We chose indoor environmental quality assessment as our research direction and designed a device that integrates BME680, STM32 microcontroller, and LCD display. By quantifying indoor VOC concentration, some basic environmental data parameters (temperature, humidity, and atmospheric pressure) are directly displayed on the display, At the same time, we can visualize VOC values through our website. These instruments provide precise methods to evaluate whether the environment meets air quality standards. They help evaluate the VOC emissions of new building materials and provide valuable indicators for the sustainability of indoor ecosystems and the well-being of residents.

5 Conclusion

In this project, we implemented a system design for VOC detection with multiple measurement capabilities. However, in high-precision environmental monitoring scenarios, the complexity, response time delay, and accuracy of gas quality measurement processes need to be improved, and the calibration and environmental adaptability of gas sensors are also issues of concern to us. In the future, we may be able to improve data accuracy, response speed, and stability by further integrating sensor technology. In addition, the BME680 sensor is expected to achieve technological breakthroughs in providing real-time and accurate environmental data to meet the rapidly growing demand for environmental monitoring in the future.

6 References

[1] "ThingsBoard - Open-source IoT Platform", ThingsBoard,2021. [Online]. Available: https://thingsboard.io/.

[2]E. Okhovat and M. Bauer, "Monitoring the Smart City Sensor Data Using Thingsboard and Node-Red," *2021 IEEE SmartWorld, Ubiquitous Intelligence & Computing, Advanced & Trusted Computing, Scalable Computing & Communications, Internet of People and Smart City Innovation (SmartWorld/SCALCOM/UIC/ATC/IOP/SCI)*, Atlanta, GA, USA, 2021, pp. 425-432, doi: 10.1109/SWC50871.2021.00064.